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The European and the Greek Business Cycles
Are They Synchronized?

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ABSTRACT

Recent developments in the business cycle empirical literature for the developed economies show that there is an increasing synchronization of the cycles in the sense that cycles are of approximately equal wave length, and exhibit similar lead-lag patterns and decreasing volatility over time, although this is not a universally accepted view. In this study I employ spectral analysis and a VAR model to evaluate the length, the volatility and the transmission mechanism of stochastic shocks between Greece and the Eurozone for the period 1980-2005 with quarterly data. The results verify that both areas exhibit lower volatility over time. However, synchronization of the cycles in terms of correlation and their transmission mechanism seems to become weaker over time.

Keywords: Business Cycle Synchronization, Transmission Mechanisms, Eurozone, Greece.

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1. Introduction

The collapse of Exchange Rate Mechanism I (ERM I) in 1979 forced the European Union to opt for the Economic and Monetary Union (EMU), as developed in the 1991 Maastricht treaty. EMU is an essential step towards European integration, as the single currency is an important factor for the effective operation of unified Europe. Single currency itself is a necessary but not a sufficient condition for the formation of an Optimum Currency Area (OCA). But, even before the formation of the European OCA i.e. the Eurozone, several papers have raised questions as to whether European countries can form such a currency area. See, for example, Bordes and Driscoll (1990), Eichengreen (1991), De Grauwe and Vanhaverbeke (1993), Caporale (1993). Relevant to this debate is whether the formation of the Eurozone leads to "two-speed" or "multi-speed" Europe, or to a unified Europe. As expected, both views have been supported by various authors. The first view, i.e. the two-speed or multi-speed Europe, has been advocated on the basis that real exchange rates are the results of real asymmetric shocks, rather than of the monetary imperfections, see Von Hagen and Neumann (1994). From a more theoretical standpoint, this view is based on the well-known thesis of Krugman (1991). Krugman argues that concentration of industrial activities leads to economies of scale and therefore, regions with specific concentration respond differently than regions with more diversified activities. The second view, i.e. that of convergence, finds its support in the argument that as regions and nations trade, the dissimilarities will tend to decrease and the economies will converge. Further, monetary and fiscal coordination will assist the convergence. See, for example, Frankel and Rose (1998), Artis and Zhang (1997, 1999 cited De Haan et al. (2002)). Given that international trade and financial transactions are much more intense during the last decades than in the past, it is expected that shocks affecting one country affect to some extent another country as well through transmission channels. Eickmeier (2004) identifies some major transmission channels, such as trade, exchange rates, final integration and confidence channel that may affect international business cycles. She concludes, though, that from a theoretical point of view, the effect of globalization on business cycle transmission, quantified by the above channels, is unclear. The whole issue is complicated by the fact that in an OCA, each participating country loses its own monetary and exchange rates instruments, which could, theoretically at least, stabilize its own output level and inflation. However, without stabilization, different countries may experience idiosyncratic cycles. Thus, because of the absence of these instruments at national level, a vital aspect of the common monetary policy is to help coordinate the cycles of different countries, and even further, the cycles of different regions within countries. In fact, it would be difficult to conceive the Eurozone as an optimum currency area if some of its member states were at the expansion phase, while other member states were at the contraction phase of their cycles. It is worth noting that synchronization of business cycle is one of the five economic tests designed by Gordon Brown to evaluate the potential entrance of the UK in the EMU. Greece, being a member state of the Eurozone, has been participating in the Eurozone since 1/1/2001, and due to this, its monetary policy is in line with the common monetary policy of the European Central Bank (ECB) and is also subject to fiscal discipline requirements. Given that its monetary and exchange rates instruments are no longer active and, additionally, that its fiscal targets are determined by the Maastricht criteria, an interesting question would be to evaluate how the short run movements, i.e. the cyclical component of the GDP series in Greece, are related to the European GDP cycle.

This study aspires to contribute to the few existing studies for Greece in two respects: *First*, it uses the most recent available data with quarterly frequency instead of yearly as previous studies have used, and, *second*, it examines an interactive transmission mechanism by means of a VAR model. In this context, the questions I address regarding the European and the Greek GDP cycles are the following: What is the length (duration) of the Greek and the European cycles? What is their absolute and relative volatility? What are the correlation, cross-correlation and the transmission mechanism between these two cycles? Are these characteristics the same over the whole period of investigation (1980-2005) or is something changing over time? My results show, *first*, that less severe cyclical fluctuations for both series are observed over time and, *second*, a weakening relationship of these cyclical fluctuations between the Eurozone and Greece and time-varying transmission mechanisms are also observed.

The paper is organized as follows: In Section 2 I examine the relevant literature. Section 3 presents briefly some descriptive measures including spectral estimates for the decomposition of the cycles and the statistical framework (the VAR model). Section 4 discusses the empirical findings and Section 5 concludes the paper.

2. Some Literature

The theoretical underpinning of the economic unification is the Optimum Currency Area, (OCA) pioneered by Mundel (1961), and later developed, *inter alia*, by McKinnon (1963), Kenen (1969), Tavlas (1993), Bayoumi and Eichenreen (1996) (cited Darvas and Szapáry (2005)). For a country to benefit from its own participation in an area with a common currency, synchronization of its business cycles is a necessary condition towards global optimization of the area. Eurozone is considered to be an OCA, or, at least, it is approaching an optimal monetary area status. This condition is deemed important because, if the cycles of, say, two countries are synchronized, then the implementation cost of the common monetary policies will be the potential minimum while, at the same time, the benefit at the potential maximum. On the other hand, non-synchronization may yield a situation where interest rate increase in the first country might be a necessary measure to reduce overheating, while, at the same time, the interest rate increase in the second country might cause or prolong recession.

The issue of synchronization of business cycles in the western economies has been considered in the following types of studies so far. *First*, studies referring to synchronization of regional cycles within a monetary union or between monetary unions such as USA and the Eurozone. *Second*, studies researching synchronization among, mainly, European countries. *Third*, synchronization among several developed economies, e.g. G7, OECD. In this last category we add some few more studies focusing on the synchronization of Greece with European and other developed economies. A key question in all these studies is whether there are similarities in the business cycles of the countries concerned. An example of studies referring to synchronization of regional cycles within a monetary union or between monetary unions such as USA and the Eurozone is De Haan et al. (2002).They find that over time business cycles in the US states have become less synchronized during the period 1929-1993. This might indicate that asymmetric shocks increased after the United States became a fully-fledged currency union in 1935. In contrast, regional business cycles in Germany have become more synchronized during the period 1950-

1996. On the basis of these findings, they argue that no clear conclusion on whether the business cycles will become more or less synchronized under EMU can be drawn. Agresti and Mojon (2001) provide a comparison between the cyclical components of the USA and the Eurozone. Using the Baxter and King (1999) filter they find the following: *First*, the GDP volatility in Euro area is lower than in the USA. *Second*, the relative volatility of some European GDP components, e.g. consumption, is similar to that of the USA. In contrast, prices in the Eurozone show lower relative volatility in comparison to the prices in the USA. *Third*, cross-correlations for both areas are quite similar in both areas, as far as GPD and its components, prices, interest rates and financial variables are concerned. On the other hand, there are several dissimilarities. For example, stock prices in the USA are positively related to growth expectations, whereas the opposite seems to hold true in the Eurozone. Further, the correlation between bank lending and GDP is higher in the USA than in Europe. Also, monetary aggregate M1 is a better leading indicator of the GDP in the Eurozone than in the USA. A series of studies focuses on the transmission shocks from one country to another, mainly the European ones. In this framework, Eickmeier (2004) studied the transmission of US macroeconomic shocks to the German economy between 1975 and 2002 by means of a large scale structural dynamic factor model. Identifying two US shocks, one medium-run supply shock and one short-run real demand shock, she finds that these shocks affect the US economy and the German economy symmetrically. This finding clearly provides evidence in favour of synchronization between the US and the German cycles. Jagrič (2002) identifies a high degree of synchronization of the Slovenian cycle with the German cycle. He explains the similarity of the business cycle of these two countries by stressing the increased openness of the Slovenian economy and the rising share of EU in Slovenian foreign trade. He also pinpoints that single currency may enhance even further business cycle synchronization. In a similar line of research, Darvas and Szapáry (2005) examine the synchronization of business cycles between new (economies under transition) and old EU members. More specifically, Hungary, Poland and Slovenia show strong improvement in cyclical correlation for the 1993-1997 period to the 1998-2002 period. Furthermore, the values of their correlation coefficients are comparable to those of several current EMU member states. On the other hand, the three Baltic countries exhibit strong correlation with Russia for the 1993-1997 period, but this correlation declined significantly for the 1998-2002 period. Referring to the old EU members, the authors observe that two groups can be identified. The "core" countries (Austria, Belgium, France, Germany, Italy and the Netherlands) which show higher synchronization, and the "peripheral" countries (Finland, Ireland, Portugal, Spain) which exhibit lower comovement. Breitung and Candelon (2001) using monthly data processed by frequency domain methods for the period 1975-1997, find that the business cycle of the UK is largely independent of the business cycles of other continental European countries. They conclude that that UK will face stabilization costs in joining the EMU. On the other hand, Austria and Germany experience highly synchronized business cycles whereas France and the Netherlands have a rather intermediate position. Christodoulakis et al. (1995) examine whether the European countries, during the period 1960 – 1990, are subject to common or different transmission mechanisms in their business cycle. They conclude that the responses of GDP, investment, consumption, prices, and to a lesser extent, net exports, show similarities among countries, even though disturbances might be of a different nature. However, responses of government spending, money supply and terms of trade vary across countries. In their opinion, these dissimilarities do not impair the integration of the European economy, provided that convergent economic policies are adopted. Luginbuhl and Koopman (2003) show evidence of synchronization in GDP cycles in Germany, France, Italy, Spain and the Netherlands for the period 1970:I – 2001:I. Using a multivariate unobserved components model, they conclude the following: *First*, the convergence of these economies had already started since 1979 with the participation in the first exchange rate mechanism. *Second*, the growth rate of Spain had already approached the average European rate since 1986 when Spain entered the Union. *Third*, the cyclical GDP movements of Italy, Spain and the Netherlands have been converging to the corresponding cycles of Germany and France since the beginning of 1990s, even before the creation of the Common Market in 1993. Finally, Stock and Watson (2002) examine the comovements of business cycles for the G7 countries. They find that volatility of economic activities has decreased over time. Although this is a common characteristic of the examined business cycles, the authors do not find evidence in favour of increased synchronization in general. Studies for business cycle in Greece have their origin in the early 50's with Voludakis (1959) being the first known researcher on the issue. More recent research is Varelas and Kaskarelis (1996), who after detrending macroeconomic series of a sample of western economies, including Greece, by means of the Hodrick-Prescot filter (HP) (Hodrick and Prescott, 1980) for the period 1960 – 1990 with annual data, and using spectral and cross-spectral methods, find that Germany, France, USA, Italy, Canada, UK and Japan experience GDP cycles whose lengths vary from 7.3 years (for USA) to 11.4 years (for Japan). In European countries, the length of the GDP cycle is about 8.5 years. Greek GDP cycle has a length of about 9.4 years, one year more than the European average. Zani et al. (2004), using both the HP filter and the first logarithmic differences as detrending methods, examine the cross-correlations and the lead – lag patterns of many macroeconomic series in Greece, with annual data for the period 1960 – 2002. The authors show that the short run cyclical movements of key macroeconomic variables e.g. GDP, consumption, investment, government spending, imports and exports, share the same features as many developed economies. However, they note that the cyclical movements of the monetary variable M1 vary across European countries.

From the above literature one cannot draw secure conclusions regarding the degree of synchronization in the developed and under transmission economies. In brief, it seems that regional cycles in the USA are less synchronized than the corresponding cycles of the UK and the USA general cycle moves together with the general UK cycle. Regarding the individual characteristics of the European cycles, the above discussion suggests that European and other developed economies tend to be characterized by cycles of approximately equal length, similar decreasing volatility over time and similar lead-lag patterns.

3. Descriptive Statistics and Transmission Mechanism

In this study I use quarterly GDP data for Greece and the Eurozone for the period 1980:I – 2005:II. The European GDP series is a synthetic variable consisting of the sum of the GDPs of the participating European countries, suitably adjusted according to the share of each country in the total GDP of the Eurozone. Both European and Greek GDP series are seasonally adjusted, in constant 2001 prices in Euros, expressed in logarithms and obtained from the OECD website. These series are decomposed into two components: the long run trend (usually assumed to be determined by technological factors affecting the aggregate production function and demographic developments) and the cyclical component, the "cycle", (assumed to be affected by short run movements, such as unexpected shocks in both demand and supply factors). Defined in this way, the cycle plus a random component is computed as "actual data – long run trend", given that data are seasonally adjusted. An estimate of the long run trend is obtained by the HP filter (1982) which is applied in the logarithms of the series. Because of this definition, the cycle expresses the percentage deviation of the actual series from its long run trend. Figures 1 and 2 present both actual data and their long run trends for both areas, Eurozone and Greece. Figure 3 displays a smoothed version of the cycle, for display purposes only, by using the HP filter on the cyclical component. From visual inspection one can identify different volatilities for Greece along the sample, with the volatility being higher in the beginning of the sample and getting lower to the end of the sample. Clearly, there must be some point at which statistical instability starts to take place. A first and exploratory in nature, device can be a regression between the Greek and the European cycle along with statistical properties of the estimated coefficients. The regression $y_t = a + \beta x_t + u_t$, with y_t the Greek cycle, x_t the European cycle, α, β parameters to be estimated and u_t a random component obeying to all classical assumptions, yields

$$\hat{\beta} = 1.01, se(\hat{\beta}) = 0.23, t[\hat{\beta}] = 4.70, R^2 = 0.18, DW = 1.77 .$$

The stability of the estimated parameter $\hat{\beta}$ is expressed by the statistics w^2 (cumulative sum of squares statistic, Brown et al. (1975)), and displayed in Figure 4. From w^2 statistics the instability of $\hat{\beta}$ is apparent after 1991 and it lasts up to 2000. Based on this findings, along with the visual fact that volatility is getting lower and lower as we move to the end of the sample, I divide the sample into three different periods: Period 1: 1980:I-1992:IV, period 2: 1993:I-2000:IV, and period 3: 2000:I-2005:II. This division also reflects the fact that since 1993 Greek economy has started to grow remarkably and that 2000 is in between 1999, the year when the Eurozone locked the exchange rates between national currencies and euro and 2001, when Greece locked its exchange rate. Hence, comparison between the periods before and after 2000 may reveal different characteristics that may be attributed to the common monetary policy and the euro.

Descriptive measures for both cycles are various correlation coefficients (Tables 1 and 2 and Figure 6), volatility, measured by the standard deviation, both in absolute and relative terms (Tables 3 and 4 and Figures 7 and 8) and the length of the cycle for the GDP of Eurozone and that of Greece. (Table 5 and Figure 5). Other results relevant to univariate spectral analysis are shown in Table 5.

Transmission mechanism of exogenous shocks is discussed next by means of a VAR model, examined as a special case within the context of cointegration analysis. The VAR model is defined as

$$\mathbf{y}_t = \mathbf{A}_1\mathbf{y}_{t-1} + \mathbf{A}_2\mathbf{y}_{t-2} + ... + \mathbf{A}_n\mathbf{y}_{t-n} + \mathbf{u}_t ,$$

where $\mathbf{y}_t$ is a $m \times 1$ vector of endogenous variables, $\mathbf{A}_i$ $m \times m$ parameters matrices $\mathbf{u}_t$ a $m \times 1$ vector of stochastic disturbances, assumed to be white noise processes. In our case $m = 2$. After suitable rearrangements (see Favero, 2001; Enders, 1995) in order to achieve stationarity we end up with

$$\Delta\mathbf{y}_t = \sum_{i=1}^{n-1} \Pi_i \Delta\mathbf{y}_{t-i} + \Pi\mathbf{y}_{t-n} + \mathbf{u}_t = \sum_{i=1}^{n-1} \Pi_i \Delta\mathbf{y}_{t-i} + \alpha\beta'\mathbf{y}_{t-n} + \mathbf{u}_t .$$

where

$$\Pi_i = -(\mathbf{I} - \sum_{j=1}^{i} \mathbf{A}_j),$$

$$\Pi = -(\mathbf{I} - \sum_{i=1}^{n} \mathbf{A}_i),$$

and $\mathbf{I}$ is a $m \times m$ identity matrix.

This reparameterized form of the initial VAR is the Vector Error Correction Model (VECM). The rank k of matrix Π gives the statistical properties of the VAR. Full rank $k = m$ implies that VAR is stationary. $k = 0$ implies that VAR is non-stationary but with no cointegrating equations. Reduced rank $k < m$ means k cointegrating equations. In this case Π can be decomposed as $\Pi = \alpha\beta'$ where α is $m \times k$ matrix of weights and β is a $m \times k$ matrix of parameters determining the cointegrating relationships. The columns of β are interpreted as long-run equilibrium relationships between the variables and matrix α determines the speed of adjustment towards these equilibria. Values of the entries of α close to unity imply high inertia and slow convergence. The $\beta'\mathbf{y}_{t-1}$ term is the equilibrium error and is a measure of the deviation from the long run equilibrium. The $\mathbf{A}$'s are $m \times m$ parameters matrices, corresponding to the lag structure of the model, determined, in practice, by an information criterion. Here I have adopted the SIC (Schwartz Information Criterion) which is

$$SIC = -2l/T + n\log(T)/T,$$

where $n = m(1 + pm)$ the total number of parameters in the VAR, m the number of equations, p the number of parameters per equation, l the log of the likelihood function under the hypothesis of the multivariate normal distribution of the error terms in the VAR and T the sample size. I select the lag which corresponds to the minimum value of SIC. Johansen (1988) and Johansen et al. (1990, 1992, 1994) have developed a statistical procedure that allows the determination of the estimation of the VAR model. This procedure is based on the fact that the rank of a matrix equals its characteristic roots that differ from zero. Having obtained estimates for the Π matrix, we associate with them the estimates for the m roots of the characteristic polynomial (the characteristic roots) of Π and order them as follows: $\lambda_1 > \lambda_2 > ...\lambda_m$. If the variables are not cointegrated, then the rank of Π is zero and all the characteristic roots are zero. In this case, each of the expressions in $(1 - \lambda_i)$ equals zero. If, instead, the rank of Π is one and $0 < \lambda_1 < 1$, then $\ln(1 - \lambda_1)$ is negative and $\ln(1 - \lambda_2) = \ln(1 - \lambda_3) = ...\ln(1 - \lambda_m) = 0$. Johansen derives a test on the number of characteristic roots that are different from zero by considering the trace and the maximum eigenvalue statistics:

$$\lambda_{trace}(k) = -T\sum_{i=k+1}^{m} \ln(1 - \hat{\lambda}_i) \text{ and } \lambda_{\max}(k, k+1) = -T\ln(1 - \hat{\lambda}_{k+1}),$$

where T is the number of observations used to estimate the VAR. The trace statistic tests the null hypothesis that the number of distinct cointegrating vectors is less than or equal to k against a general alternative. The trace statistic is zero when all λ_i are zero. The further the estimated characteristic roots are from zero, the larger the trace statistic. The maximum eigenvalue statistic tests that the number of distinct cointegrating vectors is k against the alternative of $k + 1$ cointegrating vectors. Once again, the further the estimated characteristic roots are from zero, the larger the maximum eigenvalue statistic. Both statistics are small under the null hypothesis.

Therefore, high values imply evidence in favour of the alternative hypothesis. Critical values are tabulated by Johansen and they depend on the number of the non-stationary components under the null and on the specification of the deterministic component of the VAR, both in the data and the cointegration space. Given that in the present analysis I employ the cyclical components of GDP of Eurozone and Greece, it is expected that the VAR system is of full rank $k = 2$, i.e. it is stationary. Once VAR is estimated, the transmission of stochastic shocks to the system can be monitored by reparameterizing the VAR into a moving average representation, i.e. $\mathbf{y}_t = \mu + \sum_{i=0}^{\infty} \phi_i \varepsilon_{t-i}$, *where* μ, ϕ_i and ε_t are (structural) constants, coefficients and shocks, respectively. As identification scheme, I use the Choleski decomposition with the Greek GDP cyclical component to be ordered first. This implies that structural shocks of Greece and EMU affect Greece but not vice-versa. Reversing the ordering was also tested but the results were approximately the same (not shown).

A series of tests verify that the employed series are indeed stationary. ADF test (Table 6) shows that all series are stationary at 1%, 5% and 10% significance levels. The same conclusion can be drawn from the moduli of the roots of the characteristic polynomial of the VAR (Table 8, from which we see that all moduli are less than one) and from the cointegration tests, based on the trace statistic at 1% and 5% significance levels and the maximum eigenvalue statistic at 5% significance level (Tables 9a and 9b, which show a full rank matrix Π). The stationarity of the VAR implies that this should be estimated in levels with one lag length, since this is the lag indicated on the basis of the SIC (Table 7).

The estimation of the parameters of the VAR model along with the R^2 for each period are given in Table 10. The last step in the procedure is to conduct an impulse – response analysis based on the moving average representation of the VAR. This analysis is made for all three periods for comparison reasons. The dynamic adjustment to equilibrium is given in Figures 9a and 9b and the characterization of this adjustment after the impulse of a stochastic shock, equal of one standard deviation, is given in Table 11.

4. Findings

The results of the preceding analysis can be presented in terms of the main characteristics of the cycles: Wave length, correlations and cross-correlations, volatility and transmission mechanisms of exogenous shocks. Spectral analysis shows that there are two common cycles in the Eurozone and in Greece. The first cycle has a wave length of 12.8 years and the second a wave length of 8.5 years. The estimate for Greece is close to that (9.4 years) of Varelas and Kaskarelis (1996). However, these two cycles are not of equal importance. For Eurozone, on the basis of the value of the periodogram (Table 5), the two cycles of 12.8 and 8.5 years are almost of equal importance years whereas the dominant cycle in Greece has a length of 12.8 years. Note that there is a cycle in Greece of one year length (apparent in the spectral density graphs, Figure 5) but this cannot be characterized as a cycle at typical business cycle frequencies (see Dogas 1980, 1992 for a discussion on the NBER methodology on defining the cycle). The preliminary analysis of the preceding section provides evidence that there must be a kind of instability of the relationship between the two cycles. This is obvious from the correlation coefficient which changes over time. Indeed, and for the first period (1980-1992), the correlation coefficient shows a significant relationship between the two cycles (0.496). This relationship becomes very weak in the second period (1993-2000) given that the correlation coefficient for this period is 0.252. The relationship between the cyclical GDP components ceases to exist in the third period since the correlation coefficient is just 0.126, which in practice means zero correlation. From this correlation analysis it is apparent that the two cycles do not move together over the whole time (1980-2005). Further, no significant lead-lag patterns, except in the first period at lag 1, seem to exist between the two cyclical components as only the contemporaneous cross-correlation, which is the simple correlation coefficient, is significant only in the first period (Table 2). Indeed, for the first period, cross-correlations at lags 1, 2, 3 are weak or practically inexistent (0.33, 0.19, 0.21, respectively). Another remarkable property of the two cycles is that their volatility (measured by the standard deviation) is diminishing in both absolute and relative terms, although with different rates. Hence, for the first period, the volatility in the Eurozone is 0.82% and in the third period is 0.61%. However, the big difference is for Greece. In the first period the volatility is 2.61% whereas in the third period is just 0.73%, that is, more than 3 times lower in comparison to the first period. A similar picture of declining trends is obtained in relative terms. In the first period, Greece exhibits 318% higher volatility than that of the Eurozone. In the second period, volatility is 73% higher and in the third period just 19% higher than that of the Eurozone at the same periods. Indeed, this shows remarkable decline of the cyclical variations in the Greek economy. In this context of a changing relationship, it will not be surprising that the transmission mechanism of stochastic shocks might be different. This clearly indicated in the estimation of the parameters of the VAR model (Table 10). The influence of EMU on Greece is expressed by the parameters with values 0.969, 0.458 and 0.124, corresponding to the three periods under investigation. From these values one can see the diminishing influence of the Eurozone on Greece over time. To a significant extend, this is also verified by the impulse - response analysis. For the first period the maximum shock transmitted to Greece from the Eurozone is close to 0.5% and decays in about 3 year (Figure 9a and Table 11, transmission mechanism 2). In the second period, the maximum shock transmitted to Greece from the Eurozone is close to 0.02% and decays in about 5 years. In the third period (Figure 9b and Table 9), the maximum shock is almost of zero value. This is an indication that Greece's cyclical component is affected by the Eurozone's stochastic shocks in a diminishing degree over time. A similar pattern is revealed for the transmission mechanism 1, i.e. the response of Greece to its own stochastic shocks. In the first and second period (Figure 9a and Table 11) the magnitude of the maximum value of the shock is about the same but the decay in the second period is shorter (0.5 year against 1 year in the first period). In the third period (Figure 9b and Table 11) the shock is lower but the dynamics of decay differ since now the adjustment path is oscillating. The transmission mechanism 3, i.e. the transmission of the exogenous stochastic shock originated from Greece and directed to the EMU is literally negligible (Figures 9a and 9b and Table 11). And finally, the transmission mechanism 4, i.e. the response of the EMU to its own shock, is different over time. The maximum shock in the first period is close to 0.4% and decays in about 5 years (Figure 9a and Table 11) whereas in the third period (Figure 9b and Table 11) the values now become about 0.2% for the maximum shock and more than 5 years for the decay. The above statistical findings can be summarized, *first*, as less severe cyclical fluctuations for both series over time and, *second*, as a weakening relationship, lead-lag patterns and changing transmission mechanisms over time. These results agree with the majority of the existing literature as to the first finding. However, the second finding, i.e. the weakening of the relationship between the cyclical fluctuations of Greece and those of the Eurozone, cannot be directly compared to other relevant studies due to different data periods other studies have used.

5. Conclusion

In this study I have attempted to analyze the relationship between the Greek and the European business cycles. The empirical evidence supports the view that both areas exhibit lower volatility over time but synchronization of the cycles in terms of correlation and their transmission mechanism seems to become weaker over time. How can these findings be incorporated in the discussion of the synchronization of business cycles in a monetary area such as the Eurozone? This empirical analysis and the associated evidence, however precise or imprecise, cannot justify a policy for or against the monetary union. The observed asymmetry cannot be given a unique interpretation. The opponents of the monetary union would find in the observed discrepancy the justification for abandoning the common monetary policy since each area seems to be subject to its own idiosyncratic shocks, apparent in the weakening transmission mechanisms and implying thus a phase shift of the two cycles. On the contrary, proponents of the monetary union could see in this discrepancy the need for even further coordination in order to achieve similarities in the cyclical characteristics. In some sense, the economic integration in terms of the deepening of the international trade and the financial stabilization can ensure synchronization in the cyclical fluctuations in some longer run, implying that disequilibrium is something that cannot be totally avoided. This study takes the view that the time elapsed since the beginning of the history of the EMU is not long enough to evaluate its performance or its perspective on the basis of such a small sample with continuously time-varying dynamics. In this context, more coordinated stabilization policy at the national and the European levels is required.

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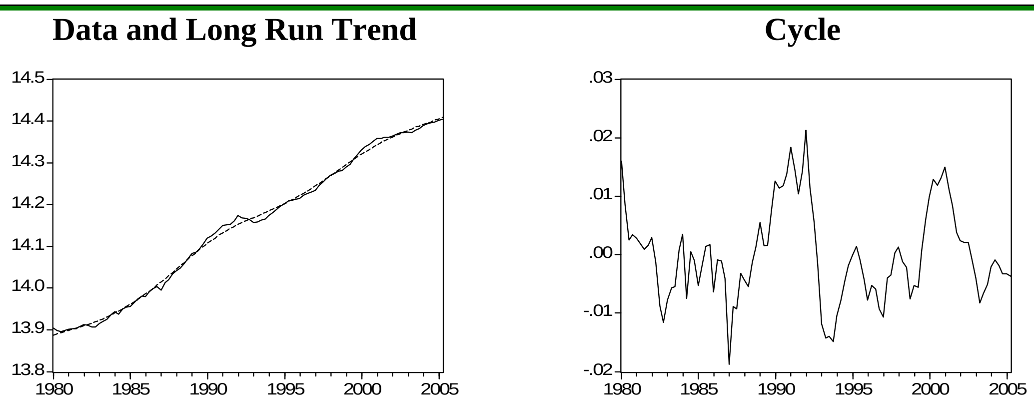
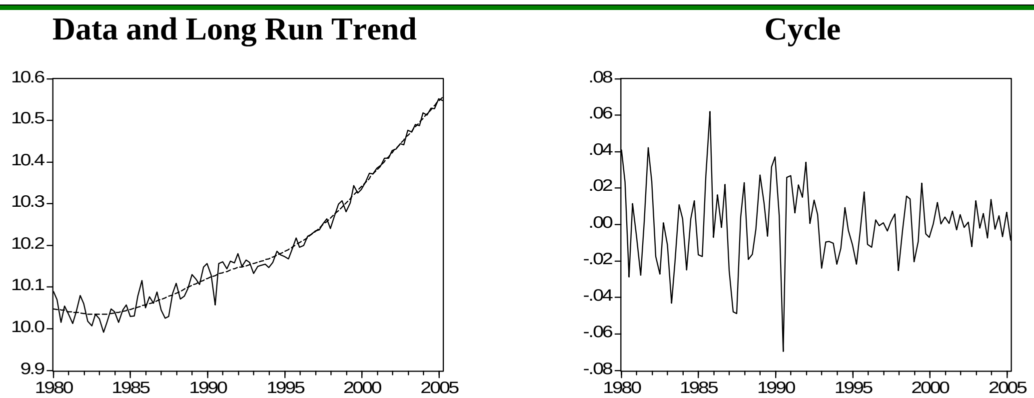
Appendix: Figures and Tables

Figure 1 GDP in Eurozone



Note: The continuous line is the long run trend, estimated by the HP filter.

Figure 2 GDP in Greece



Note: The continuous line is the long run trend, estimated by the HP filter.

Figure 3 Cycles: Smoothed version

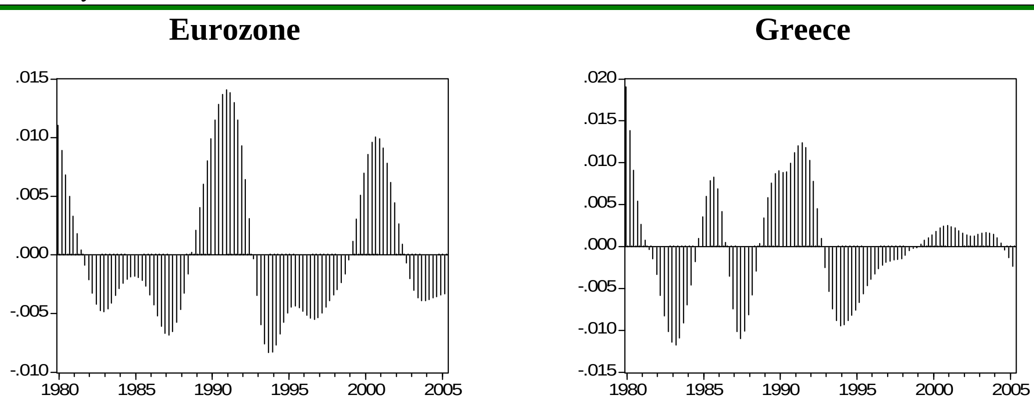


Figure 4 Stability of the estimated $\hat{\beta}$ (w^2 statistics)

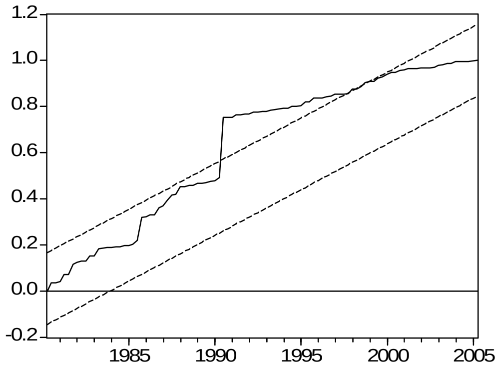
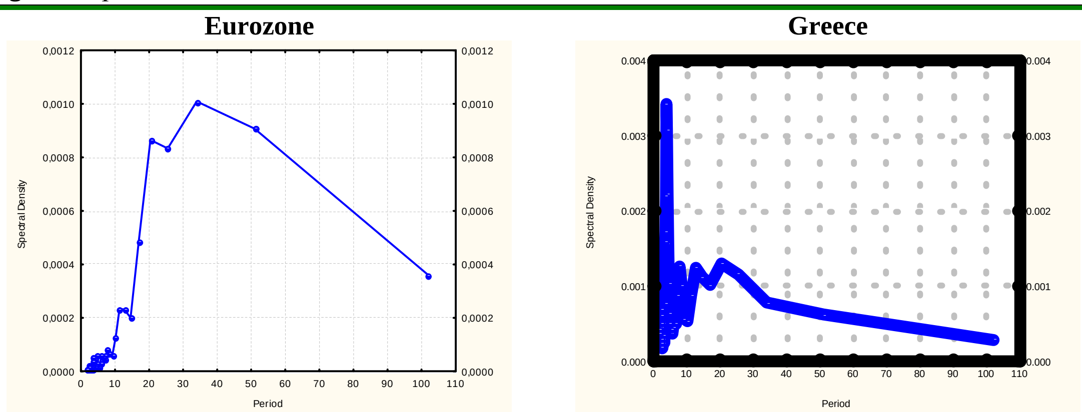


Figure 5 Spectral Densities



Note: The spectral densities are mapped on time (in quarters).

Figure 6 Correlation coefficients between Eurozone and Greece

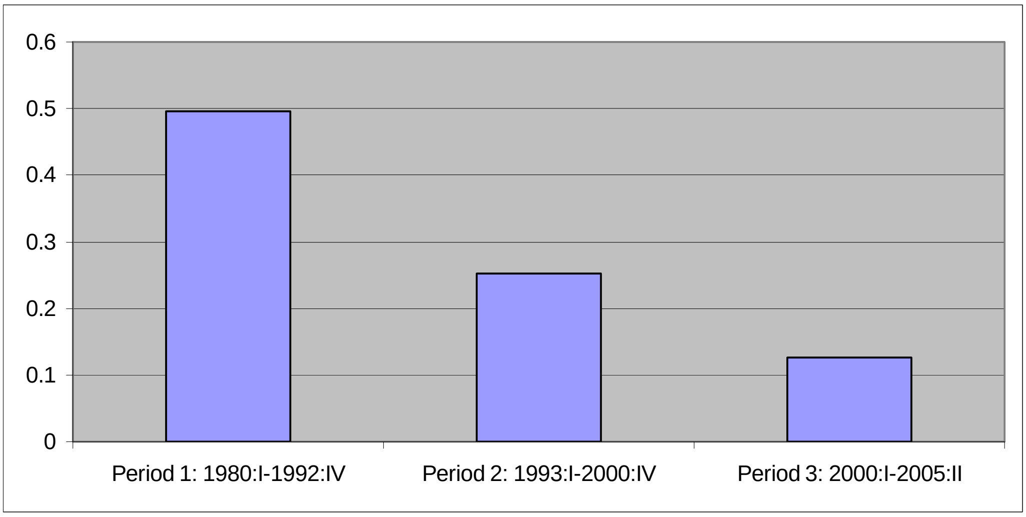


Figure 7 Standard deviation

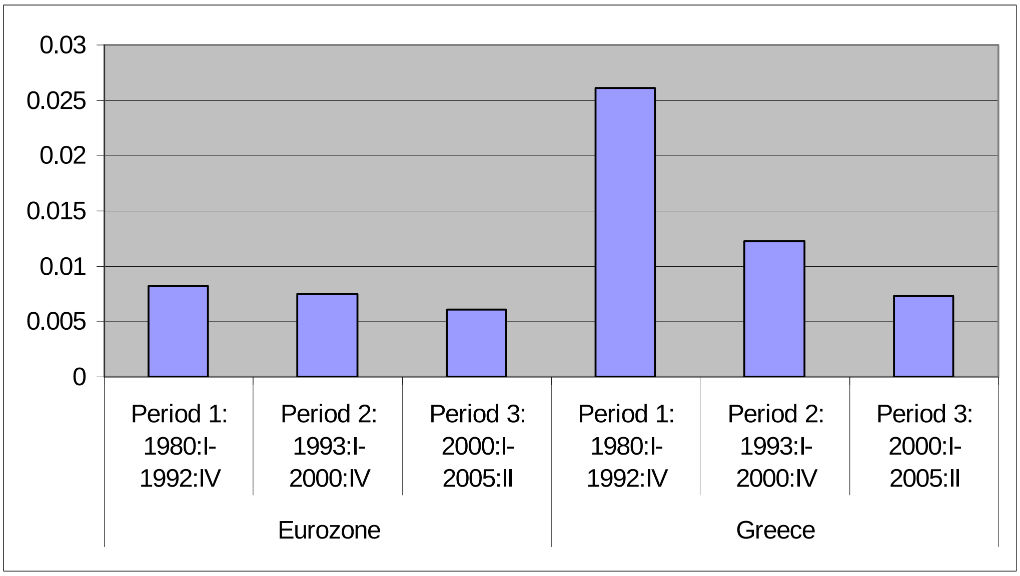
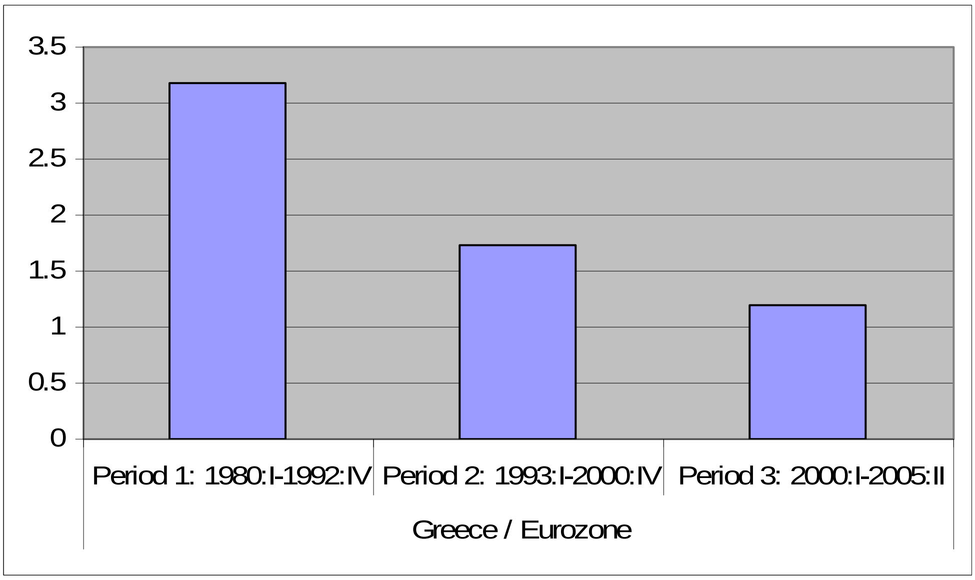


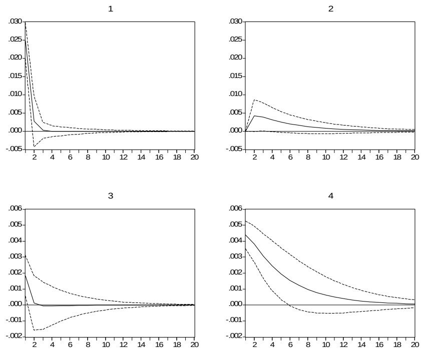
Figure 8 Relative standard deviation



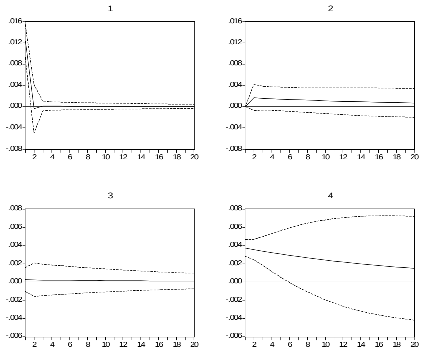
Note: The relative standard deviation is the standard deviation of Greece divided by the standard deviation of Eurozone.

Figure 9a Impulse – response analysis for periods 1 and 2

Period 1: 1980:I-1992:IV



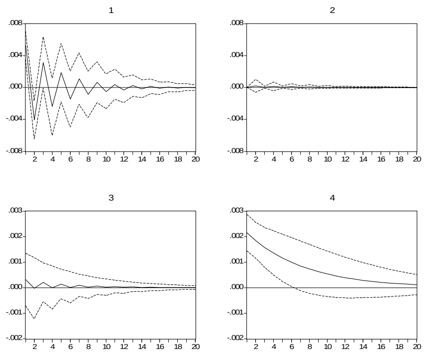
Period 2: 1993:I-2000:IV



Note: (1). Response of Greece to its own shock. (2) Response of Greece to EMU shock. (3) Response of EMU to Greece shock. (4) Response of EMU to its own shock.

Figure 9b Impulse – response analysis for period 3

Period 3: 2000:I-2005:II



Note: (1). Response of Greece to its own shock. (2) Response of Greece to EMU shock. (3) Response of EMU to Greece shock. (4) Response of EMU to its own shock.

Table 1 Correlation coefficients between Eurozone and Greece

Period 1: 1980:I-1992:IV	Period 2: 1993:I-2000:IV	Period 3: 2001:I-2005:II
0.496	0.252	0.126

Table 2 Cross correlations between Eurozone and Greece: $corr(y_t, x_{t \pm i})$

Lag or Lead i	Lag (-i)			Lead (+i)		
	1980:I – 1992:IV	1993:I-2000:IV	2001:I – 2005:II	1980:I – 1992:IV	1993:I-2000:IV	2001:I – 2005:II
0	0.50	0.25	0.13	0.50	0.25	0.13
1	0.33	0.24	0.00	0.25	0.25	0.00
2	0.19	0.23	0.11	0.10	0.19	0.12
3	0.21	0.12	-0.11	0.09	0.26	0.03
4	0.19	0.13	0.03	0.20	0.16	0.08
5	0.11	0.04	-0.12	-0.02	0.15	-0.03
6	0.09	-0.01	0.05	-0.14	0.04	0.02
7	0.14	-0.02	-0.03	0.04	0.07	-0.09
8	0.03	0.05	0.33	0.17	0.17	-0.03

Note: y_t : cyclical GDP component of Greece, x_t : cyclical GDP component of Eurozone.

Table 3 Standard deviation

Eurozone			Greece		
Period 1: 1980:I-1992:IV	**Period 2: 1993:I-2000:IV**	**Period 3: 2000:I-2005:II**	**Period 1: 1980:I-1992:IV**	**Period 2: 1993:I-2000:IV**	**Period 3: 2000:I-2005:II**
0.0082	0.0075	0.0061	0.0261	0.0123	0.0073

Table 4 Relative standard deviation

Greece / Eurozone		
Period 1: 1980:I-1992:IV	**Period 2: 1993:I-2000:IV**	**Period 3: 2000:I-2005:II**
3.18	1.73	1.19

Note: Relative standard deviation is estimated as Greece's standard deviation / Eurozone's standard deviation.

Table 5 Spectral densities

GDP Variable	C	Frequency	Period (Quarters)	Period (Years)	Cosine Coefficient	Sine Coefficient	Period.	Spectral Density
Eurozone	2	0.0196	51.0	12.8	0.0013	-0.0048	0.0013	0.0009
	1	**0.0294**	**34.0**	**8.5**	**-0.0018**	**0.0049**	**0.0014**	**0.0010**
Greece	**1**	**0.0196**	**51.0**	**12.8**	**0.0015**	**-0.0045**	**0.0011**	**0.0006**
	2	0.0294	34.0	8.5	-0.0001	0.0024	0.0003	0.0008

Note: C= Cycle. Period. =Periodogram. The dominant cycle for each variable is indicated by the bold line.

Table 6 Unit root test

Variable	ADF t-Statistic	SIC Lag Length
Eurozone	-3.22	0
Greece	-5.04	5

Note: All ADF t statistics are significant at the conventional significance levels (1%, 5% and 10%). All series are stationary. Critical values: -2.59, -1.94, -1.61 at 1%, 5% and 10% significance levels, respectively.

Table 7 Determination of optimal lag length

Lag	LogL	SIC
0	567.18	-11.97
1	631.30	**-13.14**
2	638.81	-13.11
3	639.093	-12.92

Note: LogL function takes its minimum value at lag 1. SIC: Schwarz Information Criterion. It suggests one lag length, indicated by the line in bold.

Table 8 Roots of characteristic polynomial

Root	Modulus
0.843	0.843
0.095	0.095

Note: No root lies outside of the complex plane unit circle. VAR is stationary.

Table 9a Cointegration test with trace statistic

Hypothesized Number of Equations	Eigenvalue	Trace Statistic	5% CV	1% CV
$k = 0$	0.45	80.85	15.41	20.04
$k \leq 1$	0.09	9.71	3.76	6.65

Note: Trace Statistic suggests rank of $\Pi = 2.$ VAR is stationary at both 5% and 1% significance levels. CV: Critical value.

Table 9b Cointegration test with maximum eigenvalue statistic

Hypothesized Number of Equations	Eigenvalue	Maximum Eigenvalue Statistic	5% CV	1% CV
$k = 0$	0.45	71.13	14.07	18.63
$k \leq 1$	0.09	9.72	3.76	16.65

Note: Maximum Eigenvalue Statistic suggests rank of $\Pi = 2.$ VAR is stationary at 5% significance level. CV: Critical value.

Table 10 VAR Estimates

Period	VAR Estimates	R^2
Period 1: 1980:I-1992:IV	$y_{1t} = -0.002 + 0.039 y_{1t-1} + 0.969 y_{2t-1} + u_{1t}$	$R^2 : 0.11$
	$y_{2t} = 0.000 - 0.059 y_{1t-1} + 0.871 y_{2t-1} + u_{2t}$	$R^2 : 0.67$
Period 2: 1993:I-2000:IV	$y_{1t} = -0.002 - 0.043 y_{1t-1} + 0.458 y_{2t-1} + u_{1t}$	$R^2 : 0.06$
	$y_{2t} = 0.000 - 0.003 y_{1t-1} - 0.954 y_{2t-1} + u_{2t}$	$R^2 : 0.77$
Period 3: 2000:I-2005:II	$y_{1t} = 0.002 - 0.561 y_{1t-1} + 0.124 y_{2t-1} + u_{1t}$	$R^2 : 0.31$
	$y_{2t} = 0.000 - 0.086 y_{1t-1} + 0.957 y_{2t-1} + u_{2t}$	$R^2 : 0.89$

Note: y_{1t} : cyclical GDP component of Greece, y_{2t} : cyclical GDP component of Eurozone.

Table 11 Transmission mechanisms: Pattern and dynamic convergence

Transmission Mechanism	Period 1: 1980:I-1992:IV		Period 2: 1993:I-2000:IV		Period 3: 2000:I-2005:II	
	Pattern	Convergence in years	Pattern	Convergence in years	Pattern	Convergence in years
1	Monotonic	1	Monotonic	0.5	Oscillating	2
2	Monotonic	3	Monotonic	5	Oscillating	NA
3	Monotonic	0.5	Monotonic	NA	Oscillating	NA
4	Monotonic	5	Monotonic	> 5	Monotonic	>5

Note: NA: Not Applicable.